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Research Article

Pilot Study of Guideline Adherence and Secondary Outcomes in Patients Presenting with Diabetic Ketoacidosis

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Abstract

Background: The 2010 American Diabetic Association (ADA) Guidelines for management of diabetic ketoacidosis (DKA) recommend treatment of DKA in a timely manner.

Objective: We sought to explore the quality of emergency department (ED) DKA management by comparing ED DKA management with standard ADA guidelines beyond the initial management.

Materials and Methods: This study was a retrospective study at an academic ED. Patients' age ≥ 18 years who were evaluated and treated for DKA were included. We compared ED DKA management with standard ADA guidelines in four aspects: (1) fluid administration, (2) insulin administration, (3) electrolyte correction, and (4) ED disposition. Secondary outcomes were hypoglycemia, restarting of continuous insulin infusion (CII), and rebound hyperglycemia within 24 hours.

Results: Of 75 enrolled patients, 29(39%) had mild, 16(21%) had moderate, and 30(40%) had severe DKA. All patients received intravenous fluid during their ED stay. Seventy five (100%) of cases received insulin administration in the ED. Twenty-four (44%) of cases received potassium supplement. Dextrose containing fluids was administered in 24/58(41%) of cases where blood glucose dropped <250 mg/dL. Only 14/30(47%) of severe DKA patients were admitted to ICU. Forty-six (61%) of the DKA cases treatment in the ED followed all components of the ADA guidelines. We found 12(16%) patients had hypoglycaemia. CII discontinued while still in the ED and restarted in 7/13(53%) of these patients.

Conclusion: The ADA recommended guidelines were adhered to in only two third of the time. Further studies to assess the impact of educational programs and ED-specific DKA protocols beyond stabilization are planned.

Keywords: Diabetic ketoacidosis (DKA); Guideline adherence; Emergency department (ED)

Introduction

Diabetic ketoacidosis (DKA) is one of the most serious acute metabolic complications in diabetic patients, and is rising in frequency with 80,000 discharges in 1988 to 140,000 in 2009 [1]. While the adult mortality rate from DKA is less than 1%, the mortality rate increases to 5% in elderly and in patients with concomitant life-threatening illnesses [2,3].

Patients with DKA are generally stabilized in the emergency department (ED) prior to hospital admission to either the intensive care unit (ICU), a non-ICU setting. The majority of DKA patients (87% [95% CI 81-92]) are admitted, mostly to a non-ICU setting [4]. Successful treatment of DKA is complicated, with multiple moving parts including correction of dehydration, hyperglycemia and electrolyte imbalance [5,6]. The 2010 American Diabetic Association (ADA) Guidelines for management of DKA recommend fluid resuscitation, insulin administration and electrolyte supplement in a timely manner (Table 1) [5]. The initial management of DKA in with fluid hydration, electrolyte repletion in initiation of insulin in the ED is fairly straightforward. However, as ED lengths of stay (LOS) have increased, DKA patients often are in the ED beyond the initial management phase. Further, with hospital crowding and there is sometimes pressure to save ICU beds and keep DKA patients in the ED until they can be admitted to floor units [7-9]. There are few ED-specific guidelines regarding the treatment of

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Fluid administration	0.9% NS 1-1.5 L during the first hour 5% dextrose should be added to replacement fluid once the plasma glucose is ≤250mg/dl to allow continue insulin administration
Insulin administration	Mild DKA: Start with subcutaneous rapid acting insulin analogs Moderate and severe DKA: Initial intravenous regular insulin follow by the infusion or only insulin infusion
Potassium supplementation	Serum K^+ ≤ 3.3 mmol/L hold insulin and give 20-30 mEq per hour until serum K^+ >3.3 mmol/L Serum K+ between 3.3-5.2 mmol/L, give 20-30 mEq K^+ in each liter Serum K^+ >5.2 do not give K^+ recheck electrolyte every two hours
ED disposition	If severe DKA, hypotension and/or altered mental status; admit to the ICU

DKA, Diabetic Ketoacidosis; ICU, intensive care unit

Table 1. American Diabetes Association, Diabetic Ketoacidosis Treatment Recommendations (5).

DKA patients after initial stabilization, and adherence to ADA recommendations of the management of DKA patients beyond the initial phase has not been studied. This pilot study sought to explore the quality of ED DKA management by comparing ED DKA management with standard ADA guidelines [5].

Materials and Methods

Study design and setting

This study was a retrospective study at a single tertiary academic medical center ED with an annual census of >90,000. This study was approved by our institutional review board.

Participants

We collected data from January 2012 through December 2012 in patients' age ≥ 18 years who were evaluated and treated for DKA in an urban, tertiary care hospital.

DKA patients were identified if their hospital diagnosis according to the *International Classification of disease*, 9th revision [ICD-9] code 250.10, 250.11, 250.12, and 250.13. Patients were excluded if they were transferred from other hospitals.

Methods and Measurement

DKA cases were confirmed by the presence of three or more of the following major criteria at the time of presentation: serum blood sugar ≥ 250 mg/dl, blood pH ≤ 7.3, serum HCO3 ≤ 18, serum anion gap > 10, and positive serum or urine ketone. One emergency physician abstracted charts and categorized severity of DKA according to the 2010 ADA guidelines [5].

The severity of DKA was classified as mild, moderate and severe based on published guidelines [5]. Patients with two or more criteria were classified in the higher severity group. Mild DKA was defined as plasma glucose >250 mg/dl, arterial pH 7.25-7.30, serum bicarbonate 15-18 mmol/l, urine/serum ketone positive, anion gap>10 and no change in mental status. Moderate DKA was defined as plasma glucose >250 mg/dl, arterial pH 7.00 to <7.24, serum bicarbonate 10 to <15 mmol/l, urine or serum ketone positive, anion gap>12 and no change in mental status or drowsiness. Severe DKA was defined as plasma glucose >250 mg/dl, arterial pH <7.00, serum bicarbonate <10 mmol/l, urine or serum ketone positive, anion gap>12 and stupor or coma. To assess reliability of determining severity, a second reviewer, an endocrinologist, reabstracted the charts. Interrater reliability was excellent with *k* value=0.91 (0.84-0.99).

Outcomes Measure

The primary outcome was to compare ED DKA management beyond the initial phase with standard ADA guidelines. We compared four aspects (Table 1): (1) fluid administration, (2) insulin administration, (3) electrolyte correction, and (4) ED disposition.

Specifically, we collected patient demographics, 1) fluid administration: time of fluid order and administration, amount of fluid administered in the initial 4 hours, 2) insulin administration: time of first insulin order and administration, type and route of insulin administration, 3) electrolyte correction: laboratory result time, potassium correction dose and time, and 4) ED length of stay, ED disposition time and place were collected.

The secondary outcomes were defined as (1) hypoglycemia; defined as serum glucose ≤ 50 mg/dl within 24 hours, (2) rebound hyperglycemia; defined as the value of serum glucose ≥ 450 mg/dl after being treated to target blood sugar within 24 hours, and (3) restarting insulin drip; defined as restarting intravenous insulin for any reason within 24 hours.

Statistic

Categorical data were presented as percentages. Continuous data were records as mean with standard deviation (SD) if normally distributed or medians with inter-quartile ranges (IQR) if non-normally distributed. Microsoft Excel 2007 was use for data entry and analysis.

Results

Characteristics of study participants

A total of 75 patients with initial presentation to our ED with DKA were identified. Their baseline characteristics are detailed in Table 2. Only a minority of cases, 8%, were in the setting of newly diagnosed diabetes. Forty-four (59%) cases were attributed to missed insulin dose. It is notable that 44 (59%) of cases involved alcohol or illicit substance use. The distribution in severity of DKA was 39% presenting with mild, 21% with moderate, and 40% with severe DKA.

Main Results

The majority (63%) of patients were admitted to the general medicine service, and 24% to intensive care post-ED treatment. The median ED LOS was 6.8 (4.7, 9.6) hours. All patients received intravenous fluid (IVF) during their ED stay, with 46 (61%) receiving at least one lite of normal saline (NS) within the first hour recognition of DKA. Potassium was treated according to recommended guidelines in 44% of cases. Dextrose containing fluids were administered in 24 of the 58 cases where blood glucose (BG) dropped <250 mg/dL. Insulin was administered in the ED in 100% of cases, with 48% receiving an an intravenous insulin push and 27% receiving subcutaneous insulin for their first dose. The majority of patients 51 (68%) received continuous insulin infusion (CII) therapy in the ED. Patients with moderate

Variable	
Age, mean ±SD, years	40 ± 15
Male, n (%)	44 (59)
Type 1 diabetes, n (%)	50 (67)
New diagnosis of diabetes, n (%)	6 (8)
Contributing factors to DKA, n (%)	
Missed insulin dose	44 (59)
Alcohol use	35 (47)
Other substance abuse	19 (25)
Means of arrival to ED, n (%)	
Walk-in,	32 (43)
Ambulance	43 (57)
DKA Severity, n (%)	
Mild	29 (39)
Moderate	16 (21)
Severe	30 (40)
Post-ED Disposition, n (%)	
ICU	18 (24)
General Medical Floor	47 (63)
ED Observation Unit	10 (13)
ED LOS, median (IQR), hours	6.8 (4.7, 9.6)
Hospital LOS, median (IQR), hours	58 (34.3, 98.2)
Charlton Comorbidity Index, mean ±SD	1.3 ± 1.7
Baseline Laboratory Results	
Glucose, mean ±SD, mg/dL	544 ± 208
Bicarbonate, mean ±SD, mmol/L	13.2 ± 6.5
pH measured in ED, n (%)	66 (88)
Ketones status assessed in ED, n (%)	44 (59)
Treatment	
Intravenous Fluid, total, mean ±SD, cc	
1 hour in ED	181 ± 441
2 hours in ED	813 ± 1,000
4 hours in ED	1,984 ± 1,000
Within 1h after lab results, mean ± SD, cc	885 ± 500
Potassium <5.2 mmol/L in ED, n(%)	54 (72)
Received KCl repletion in ED, n	24
D5 fluids started once BG<250 mg/dL (n=58), n(%)	24 (41)
Time from ED arrival to Chem7 result, median (IQR), minutes	55 (27, 88)
Insulin Ordering and Adminstration, median (IQR), minutes	
Time from ED arrival to 1st insulin order (n=75)	76 (39, 148)
Time from ED arrival to insulin admin	105 (57, 206)
Time from ED arrival to IV insulin order (n=58)	86 (53, 192)
Time from ED arrival to IV insulin admin	158 (32, 262)
Route of first Insulin Administration, n(%)	
IV insulin drip	19 (25)
IVs insulin push	36 (48)
Subcutenous insulin	20 (27)
IV insulin drip started	58 (68)

DKA, Diabetic Ketoacidosis; ED, Emergency Department; ICU, Intensive Care Unit; LOS, length of stay; KCl, potassium chloride; IV, intravenous fluid; BG, blood glucose

Table 2: Baseline characteristics and treatment of DKA patients treated in ED, n=75

or severe DKA (n=46) were treated with continuous IV insulin infusion 85% of the time. Of the 30 patients with severe DKA, 14 (47%) were admitted from the ED to the ICU. Treatment in the ED followed all 4 components of the ADA guidelines for treatment of DKA in 46 (61%) of the cases (Table 3).

Guideline Recommendations	Adherence in ED, n (%)
IVF 1-1.5 L during first hour*, n=75	46 (61)
Addition of D5 fluids once PG ≤250 mg/dL, n=58	24 (41)
Insulin Administration	
Subcutaneous insulin for Mild DKA, n=29	13 (45)
Intravenous insulin for:	
Moderate DKA, n=16	11 (69)
Severe DKA, n=30	28 (93)
K^+ replacement when K^+≤5.2 mmol/L, n=54	24 (44)
Severe DKA admitted to ICU, n=30	14 (47)

*Fluid administration calculated 1 hour after laboratory chemistry result.
D5, 5% dextrose; DKA, diabetic ketoacidosis; K+, potassium

Table 3: Comparison between ADA guideline and ED practices.

We found 12 (16%) patients had hypoglycemia within 24 hours of presentation, one occurring in the ED. Continuous insulin infusion was discontinued while still in the ED in 13 of the 51 patients who received CII. Continuous insulin infusion was restarted in seven of these patients, none while in the ED. Rebound hyperglycemia was found in one patient.

Discussion

We found that ADA recommended guidelines were adhered to in only 61% of the time, with the majority of the deviations from the guidelines from patients with severe DKA not being admitted to an ICU setting and the failure to initiate D5 containing fluids when BG reached <250 mg/dL. Twenty-five percents of patients had an adverse event occur during their hospital stay, mainly from hypoglycaemia from not starting D5 containing fluids in a timely fashion and from prematurely stopping CII.

There has been little focus on the treatment of DKA in the ED beyond initial fluid resuscitation, insulin administration and electrolyte repletion. However given the average ED LOS in US for admission patients is 269 minutes (IQR 171-397) overall and 236 minutes (IQR149-371 minutes) waiting for ICU beds, and are increasing over time [10]. The median ED LOS of our patients presenting with DKA was six hours, all of which are crucial to the optimal management of these patients. While an ideal world, patients presenting with DKA are admitted quickly for treatment, given the longer LOS and crucial first hours in treatment of DKA, ED training should include management beyond the first few hours and/or incorporate ED-centered templates for clinical decision support to ensure safe patient care.

Limitations

This study had several limitations including being limited to a single study and a relatively small sample size. Furthermore, given we conducted our study in an academic center where DKA can be managed in a non-ICU setting, results may not be generalizable.

Conclusion

This pilot study was intended to investigate the management

of DKA beyond the initial resuscitation window in the ED; it highlights the variability in DKA treatment in the ED and potential impact on adverse events and patient safety post-ED care. Further studies to assess the impact of educational programs and ED-specific DKA protocols/templates on DKA management beyond stabilization are planned.

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